

IN THE SPECIFICATION

Please add the Cross Reference to Related Applications section:

CROSS REFERENCE TO RELATED APPLICATIONS:

This Application is a continuation of and claims priority to U.S. patent application serial number 09/929,324, filed on August 14, 2001, entitled " **SOLID STATE TEMPERATURE MEASURING DEVICE AND METHOD,**" the entire contents of which are incorporated herein by reference.

Page 1, lines 15-23, please amend the paragraph as follows:

Numerous methods exist to measure temperature by using electronic devices such as semiconductors and resistors. Semiconductor devices used vary from a simple, low cost diode to a pair of transistors, specially manufactured for high temperature-accuracy of temperature measurement. Other devices use resistors of varying stability to support a highly accurate and easily calibrated temperature measuring device. The resistors are placed in a Wheatstone bridge configuration. A Wheatstone bridge is a common technique wherein a probe, typically a thermistor, causes the bridge to become unbalanced as the temperature changes. The temperature changes sensed by the probe cause the bridge to transmit an analog signal.

Page 2, lines 5-13, please amend the paragraph as follows:

A widely used temperature measurement device 100 in FIG. 1A uses a simple, low cost diode in which a constant current I_A is applied from a current source. Every diode 104 has a constant called the Boltzman constant (K) and a junction voltage at the base emitter 08 ~~of the diode junction voltage with varies with temperature~~. This voltage shift with temperature is called the slope of the diode, (S). The voltage 106 across the diode is proportional to the temperature based upon the Boltzman constant and junction voltage

~~change per degree Celsius change, or represented of the junction represented by the equation~~
 $T = K - S/\text{degree Celsius}$. The slope S and the constant K are measured in millivolts. In addition, each diode junction voltage 108 or slope has an error term as the diode heats up because of the constant current source 102.

Page 3, lines 11-19, please amend the paragraph as follows:

FIG. 1B shows a specially manufactured transistor circuit 150 for measuring temperature. This circuit 150 improves measuring accuracy at a much greater cost than the single diode device 100 of FIG. 1A. A pair of transistors 158 and 160, having a known surface base-emitter junction area ratio, are inputs to a differential amplifier 166. A voltage 152 is applied across the transistors 158, 160 and a pair ~~a~~ of resistors 154, 156 to draw currents 162 and 164 through the transistors. The ratio ~~of the surface ratio areas~~ of the base-emitter current density of the transistor pair 158 and 160 yields a known slope. The error term of the junction voltage at the base emitter cancels out when the current density or surface area of each transistor is controlled at the time of manufacture. ~~The slope, S, of each transistor is known after manufacture.~~

Page 4, lines 13-25, please amend the paragraph as follows:

The cold junction or reference temperature circuit used in thermocouple-based devices of other devices leads to additional cost and engineering complexity. Without a cold junction temperature, the actual measurement has no baseline. Additional circuitry provides a cold junction analog signal as an input to the circuitry of the temperature measuring device. The additional circuitry narrows the use of the temperature measuring devices. The narrowed use results from a need to improve accuracy and reduce the calibration time. Electronic circuits lose accuracy because of the heat generated from current used to power the circuit itself. To compensate for lost accuracy, the circuit designers tend to use more expensive electronic components and design for narrower temperature ranges. Designing for narrower

temperature ranges allows one to apply the electronic circuit accurately to the narrower range, resulting in a higher resolution much like microscope at high power. The additional circuitry has more stable resistors, power amplifiers, and specially manufactured transistors.

Page 4, lines 31-34, please amend the paragraph as follows:

The temperature circuit of FIG. 1B has better accuracy than FIG. 1A and a wider temperature range than FIG. 1A. However, the circuit of FIG. 1B requires careful matching of the diodes used in base emitter of transistors 158 and 160 at manufacture. In addition, more circuitry is required to measure the analog signal proportional to the temperature measured.

Page 5, lines 5-18, please amend the paragraph as follows:

SUMMARY OF THE INVENTION

The present invention provides a method and system for automated temperature measurement. The system, on which the method is based, includes a programmable logic controller, a temperature measurement diode, an analog-to-digital converter coupled to the diode and the programmable logic controller, a current source coupled to the diode and configured to generate a first current and a second current different from said first current, and a processor coupled to the current source and to the analog-to-digital converter. The processor controls the current source such that the current source sequentially applies the first current to the diode at a first point in time and applies the second current to the diode at a second point in time. The processor also receives a digital representation of a first voltage across the diode measured when the first current is applied to the diode and a second digital representation of a voltage across the diode measured when the second current is applied to the diode. Based on these digital representations of the first and second voltages, the processor determines the temperature proximate the diode.

Page 6, lines 7-9, please amend the paragraph as follows:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 4 is a flowchart explaining how the present invention ~~calibrates~~ measures the temperature measuring device in accordance with an embodiment of the present invention; and

Page 6, lines 13-24, please amend the paragraph as follows:

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 2A thereof, there is shown a conceptual diagram of an exemplary programmable logic controller (PLC) system of the present invention. PLC 214a, temperature units 300c and 300d, and I/O module 216e communicate over network 204b, and PLC 214b, 214c, I/O modules 216a and 216b, and temperature units 300a~~1~~ and 300b communicate over network 204a.

Page 6, line 31, through page 7, line 10, please amend the paragraph as follows:

I/O modules 216a, 216b, 216c, 216d, and 216e are hardware for sending and receiving data. In particular, the I/O modules 216 of FIG. 2A deliver commands to the temperature units 300a, 300b, and 300c to cause the temperature units 300 ~~to calibrate and to measure~~ temperature. The I/O modules 216 also receive temperature measurement information from the temperature units 300. I/O modules 216 may be implemented as cards that are inserted into a PLC (such as I/O modules 216c and 216d) or as hardware that is connected to the same backplane or network as the PLCs 214 and the temperature units 300.

Page 7, lines 8-16, please amend the paragraph as follows:

The temperature units or measuring devices 300a, 300b, 300c, and 300d ~~are calibrate~~ and measure the temperature of any surface to which they are thermally coupled. The

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temperature units 300 may be connected to one or more of the PLCs 214 in the system in any number of ways. For example, temperature unit 300a is connected directly to I/O device 216b, temperature units 300b and 300c are connected directly to networks 204a and 204b, respectively, and temperature unit 300d is connected directly to PLC 214a (e.g., via the I/O module 216d). The temperature units 300 communicate status information and temperature measurements to one or more of the PLCs 214 via I/O modules 216.

Page 8, lines 10-20, please amend the paragraph as follows:

Once the two digital voltage values are read by PLC 214, PLC 214 calibrates ~~the temperature measuring system calculates the temperature using the Ideal Diode Equation.~~ ~~The Ideal Diode Equation measures the temperature in degrees Kelvin as proportional to the change in voltage. The Ideal Diode Equation is given by the following equation~~ $\Delta V_{BE} = V_{BE1} - V_{BE2} = \eta kT/q \ln(J_{E1}/J_{E2})$. V_{BE1} is the first voltage measurement and V_{BE2} is the second voltage measurement. ~~Most designs use two diodes, which require the current density (j) of each diode as a variable in the Ideal Diode Equation.~~ K is the Boltzman constant and q is the charge on the electron. Both K and q are known and fixed, ~~unlike the one.~~ In this embodiment, one diode is used for both measurements, thus the ratio of the current densities of the diodes J_{E1}/J_{E2} is equal to the given ratio of currents I_1 and I_2 and the correction term $\eta = 1$. In an alternative embodiment with two diodes, it is necessary to account for the fact that no two diodes are manufactured alike (thus J_{E1} may not equal J_{E2} for a given current density) and each diode has inaccuracies. These factors are compensated for by a predetermined constant η . In the present invention, both η and the current density's J_{E1} and J_{E2} ~~when the same diode 308 is used.~~

Page 11, lines 30, through page 12, lines 8, please amend the paragraph as follows:

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In step 502 the processor 312 causes the current source to apply the first current to the diode 308 and causes the A/D converter 310 to measure and store the voltage across the diode 308. In step 504 the processor 312 causes the current source to apply the second current to the diode 308 and causes the A/D converter 310 to measure and store the voltage across the diode 308. In step 506 the processor 312 subtracts the digital representation of the voltage resulting from the higher current from the digital representation of the voltage resulting from the lower current. Thus, if the second current is greater than the first current, then the first second-voltage is subtracted from the second-first voltage. In step 508, the difference between the first and second voltages, obtained in step 506, is digitized by the analog-to-digital converter.

Page 12, lines 8-13, please amend the paragraph as follows:

Then, in step 509, the digitized difference in the voltages is transmitted to the processor 312. In step 510, the temperature of the mass or body proximate the diode is determined by the processor by multiplying the difference between the voltages by a constant, using the Ideal Diode Equation, derived from the previously described equation $\Delta V_{BE} = V_{BE1} - V_{BE2} = \eta kT/q \ln(J_{E1}/J_{E2})$. For the single diode embodiment $\eta = 1$ and the This constant is the inverse ratio of the Boltzman constant, k , and the charge on the electron, q . The resulting product is the temperature of the surface to which the diode 308 is mounted in degrees Kelvin. Optionally, an additional scaling function can be used to convert degrees Kelvin to another temperature scale (e.g., Fahrenheit or Celsius).

Page 12, lines 21-30, please amend the paragraph as follows:

As explained above, the temperature system and method of the present invention has a single diode having a first end operably connected to a pair of current sources, and having a second end connect to ground. The single diode or transistor junction is in thermal communication with a heat conducting surface. At the start-up of a system in which the device resides, a

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microprocessor starts the calibration cycle. The microprocessor turns on the current sources. This starts a first current to flow through the diode circuit. Shortly thereafter, the microprocessor signals an analog-to-digital converter to read the voltage drop across the diode. The analog-to-digital converter reads the voltage and converts the analog signal to a digital signal. The microprocessor reads the digital signal and stores the value in a first temporary memory.

Page 13, lines 8-12, please amend the paragraph as follows:

Having the analog voltage signal of both current flows converted to a digital value, the microprocessor determines the temperature PTAT of the diode circuit. Using the ideal diode previously described equation and a known ratio of currents, the microprocessor can determine the slope, S , and with the Boltzman constant, K , of the diode itself the output voltage proportional to the actual temperature measured can be determined during operation of a PLC system.